Int. j. adv. multidisc. res. stud. 2024; 4(3):1341-1344

Received: 28-04-2024
Accepted: 08-06-2024

International Journal of Advanced Multidisciplinary Research and Studies

ISSN: 2583-049X

Relationship between Climate Factors, Temperature, and Humidity, and the Incidence of Dengue Cases in Mexico

[1] Prestegui Muñoz José Ángel de Jesús, [2] Ortiz Cornejo Eduardo, [3] Prestegui Muñoz David Eduardo, [4] Rodriguez Álvarez Karen Guadalupe

[1] Internal Medic. Regional General Hospital "Primero de Octubre". Mexico City, Mexico
[2] Internal Medic. Regional General Hospital number 72 of Tlalnepantla. Mexico City, Mexico
[1, 2] Medical Student, National School of Medicine and Homeopathy of the National Polytechnic Institute, Mexico City, Mexico
[3] Department of Cardiology, Regional General Hospital "Adolfo Lopez Mateos " Mexico City, Mexico
[4] Department of Nephrology, General Hospital of Mexico "Eduardo Liceaga", Mexico City, Mexico

DOI: https://doi.org/10.62225/2583049X.2024.4.3.2943
Corresponding Author: **Prestegui Muñoz José Ángel de Jesús**

Abstract

Introduction: Dengue is an arbovirus that causes the disease dengue, transmitted primarily by mosquitoes, especially Aedes aegypti. The disease is characterized by an acute febrile illness with temperatures that can rise up to 40°C, accompanied by symptoms that disrupt the patient's general well-being. It is possible to analyze a potential ecological triad to assess the risk of contracting dengue, which includes the transmitting mosquito and the virus, a climate conducive to vector reproduction, and a relatively susceptible population.

Materials and Methods: This retrospective study utilized data obtained from Dengue non-severe morbidity yearbooks published from 2012 to 2023, as well as temperature and precipitation data for the states from the official CONAGUA website for the same years. This research only required computers with internet access for data collection. Statistical analysis was performed using SPSS 25.0. The Shapiro-Wilk test was used to determine the normal distribution of variables, considering year, temperature, river precipitation, and dengue cases as continuous variables and comparing them using the Student's t-test. Correlation analysis was conducted using the Pearson parametric test.

Results: A high positive correlation ($r=0.68$, $p=0.004$) was found between dengue and temperature, and a moderate positive correlation ($r=0.55$, $p=0.02$) was observed between dengue and river precipitation.

Conclusions: The general hypothesis was confirmed by establishing that temperature and river precipitation factors influence the increase in dengue cases due to the vector's ease of reproduction under these conditions. States with a tropical climate have a higher incidence of dengue cases compared to states with a dry climate.

Keywords: Dengue, Arbovirus, Aedes Aegypti, Epidemiology, Climate, Latin America, Mexico

1. Introduction

Dengue is a virus belonging to the arbovirus family, specifically in the Flaviviridae family, and it is the most common of its kind worldwide. It is transmitted by mosquitoes of the Aedes genus, primarily by Aedes aegypti and Aedes albopictus.

The disease, also known as dengue, is characterized by an acute febrile illness with temperatures that can rise up to 40°C, accompanied by frontal headache, retroorbital pain, myalgia, arthralgia, and rash. This clinical presentation, known as dengue fever (DF), can be confused with leptospirosis, yellow fever, and influenza, among others. Some patients progress with intense pain, high fever, increased vascular permeability, bleeding, hemoconcentration, and thrombocytopenia; this condition is referred to as dengue hemorrhagic fever (DHF) [1, 12].

One could analyze a possible ecological triad to assess the risk of contracting dengue, in which we can observe the presence of the transmitting mosquito and the virus, the climate, and a relatively susceptible population. On the other hand, we can consider an epidemiological triad, in which the population becomes more susceptible if climatic conditions are favorable. An example of this occurs during the rainy season when mosquito proliferation is higher. Furthermore, this becomes a more significant problem when there is a geographically favorable zone for vector survival, such as tropical and subtropical regions, which are the highest-risk areas for contact with the dengue virus.

1.1 Current Situation of Dengue in Latin America

It is said that the spread of dengue in the Latin American region has evolved over nearly 30 years. During the 1950s, the Pan American Health Organization (PAHO) implemented a campaign in the Latin American region that concluded in the early1960s. However, the number of countries reinfested with the vector mosquito reached levels similar to those before the campaign.

The occurrence of classic dengue along with dengue hemorrhagic fever currently affects most of the American continent and some Caribbean islands. In just the first 5 months of the year 2020, PAHO reported that dengue cases exceeded 1.6 million, with an increase in the incidence rate in countries such as Honduras, Nicaragua, and Mexico [2, 7].

1.2 Current Situation of Dengue in Mexico

Dengue in our country had its confirmed appearance in the early 1940s when 6,955 cases were reported, with a rate of 34.4 per 100,000 inhabitants. These figures decreased as the vector was gradually eradicated, with its eradication being officially recorded by PAHO in 1963.

However, by the late 1970s, there was almost an immediate reinfestation, leading to an increase in transmission cases, primarily near the southern border. In 1978, cases of dengue were diagnosed in Tapachula, Chiapas [5].

Due to this alarming situation, an alert campaign for dengue diagnosis was carried out throughout the southern region. Nevertheless, the disease spread in subsequent years to Oaxaca, Veracruz, Yucatán, Quintana Roo, among others.

During the 1980s, dengue maintained a moderate incidence rate, but over the years, it became a significant cause of medical consultations and hospitalizations in areas where the vector was present.

In 1994, 8,072 cases were recorded, including 30 cases of dengue hemorrhagic fever. This marked the point where the diagnosis of dengue hemorrhagic fever began to gain importance in Mexico.

This underscores an important fact, as noted by the author José Narro-Robles:

"The significance of identifying cases highlights the shift in the clinical spectrum of the disease and compels us to consider this event as a serious warning about the possibility of the emergence of severe cases in an epidemic manner".

Subsequently, from 2000 to 2004, there was a low endemic period. However, in the last 20 years, new outbreaks have occurred in 2007, 2009, 2012, 2013, and the most recent in 2019 [3, 4].

1.3 Vector and Risk Factors Favoring its Reproduction

The vector for the Dengue Arbovirus is the female Aedes aegypti mosquito. This species is thermophilic and thrives in regions with tropical and subtropical climates around the world. It originally evolved in Africa and spread to the Americas thanks to exploratory expeditions and colonizers [2, 15].

The hematophagous nature of the female mosquitoes, which feed on the blood of humans and domestic animals, necessitates their proximity to human settlements.

The mosquito's life cycle begins with the deposition of eggs by adult females on the moist walls of natural or artificial containers that hold water and are located in areas with limited sunlight. The eggs, attached to the container walls, can incubate for days or even months until contact with water stimulates their hatching [10, 11]. The larva emerges from the egg and immerses itself in the water, where it develops into a pupa, a stage that lasts about 2 to 3 days before it becomes an adult mosquito [8]. Newly matured females can feed on a human infected with the Dengue virus. The virus is absorbed in the mosquito's stomach and then spreads to all its organs, primarily accumulating in the salivary glands [9].

Once the Dengue virus accumulates in the salivary glands, if an infected female feeds on another human, she is capable of transmitting the Dengue virus through biting and inoculation until the end of her life, which typically lasts between 6 and 8 weeks [9, 15].

1.4 Climate and Sociodemographic Conditions in Veracruz, State of Mexico, Michoacán, and Querétaro

Firstly, we have the state of Veracruz, which predominantly features a warm subhumid and humid climate, making it ideal for the propagation of mosquitoes.

In terms of its population, according to data collected by the INEGI (National Institute of Statistics and Geography) in 2015, it was estimated to have a population of 8,112,505 inhabitants, distributed as 61% in urban areas and 39% in rural areas. Veracruz has a maximum altitude of 5,610 meters above sea level (Pico de Orizaba) and a minimum altitude of 0 meters above sea level (Coast) [4].

Michoacán has a mix of climates, including warm subhumid and temperate subhumid, as well as dry and semiarid climates, unlike Veracruz. The population of Michoacán is 4,584,471 inhabitants, with a distribution of 69% in urban areas and 31% in rural areas. The state has a maximum altitude of 3,840 meters above sea level (Cerro "Pico de Tancítaro") and a minimum altitude of 0 meters above sea level (Coast) [6].

On the other hand, we have states in the central region, namely the State of Mexico and Querétaro. The State of Mexico primarily features a temperate subhumid climate and has a population of 16,187,608 inhabitants, distributed as 87% in urban areas and 13% in rural areas. Its maximum altitude is 5,380 meters above sea level (Volcán Popocatépetl), and its minimum altitude is 420 meters above sea level (Presa Vicente Guerrero). Querétaro, on the other hand, has predominantly dry and semiarid climates, along with some warm subhumid areas. It has a population of 2,038,372 inhabitants, with a distribution of 70% in urban areas and 30% in rural areas. The state has a maximum altitude of 3,340 meters above sea level (Cerro "El Zamorano") and a minimum altitude of 440 meters above sea level (Municipality of Jalpan de Serra) [13, 14].

2. Metods

To assess dengue control and prevention measures in various geographical regions, we selected several dengue-affected areas in Mexico, including Veracruz, State of Mexico, Michoacán, and Querétaro. We employed a Likert scale ranging from 1 to 6, where 1 represents "No measures" and 6 represents "Mandatory for all," to classify measures according to their level of implementation and obligatoriness. We conducted assessments at different time periods, such as T1 (e.g., January to March) and T2 (e.g., April to June), to track the evolution of measures in each region. We collected data on the implemented measures and analyzed their impact on dengue incidence in each area, allowing us to compare the effectiveness of measures at different times and locations.

This research aims to analyze and, above all, highlight the presence of dengue in federal entities where there is a considerable difference in temperature, precipitation, and population density, indicating through the parametric "Student's t-test" the relationship between these factors and the occurrence of dengue cases.

Based on the information provided by the World Health Organization, it is evident that the distribution of Dengue cases is primarily in urban and semi-urban areas, where the climate is mostly tropical and subtropical.

Therefore, the population not located in these regions may have a false sense of not being at risk and, consequently, may not take appropriate measures to prevent the breeding of the mosquito responsible for causing this disease. However, the presence of cases is observed in federal entities that do not have the favorable climatic conditions for vector development.

3. Results

Statistical analysis was conducted using the SPSS 25.0 software package. A significance level of $P \leq 0.05$ was considered as statistically significant. The Shapiro-Wilk test was employed to assess the normal distribution of variables. Continuous variables were presented as means and standard deviations or medians, and comparisons were made using the Student's t-test. Correlation analysis was performed using the Pearson parametric test.

Four variables were analyzed: Year, river precipitation, temperature, and the number of new dengue cases, with a sample size (n) of 16. The sample was divided into two groups based on climate characteristics, with Michoacán and Veracruz (Group A) classified as having a tropical climate, and the control group consisting of the State of Mexico and Querétaro (Group B) with a dry climate. All variables showed a normal distribution, enabling the application of the Student's t-test for analysis, leading to the following findings.

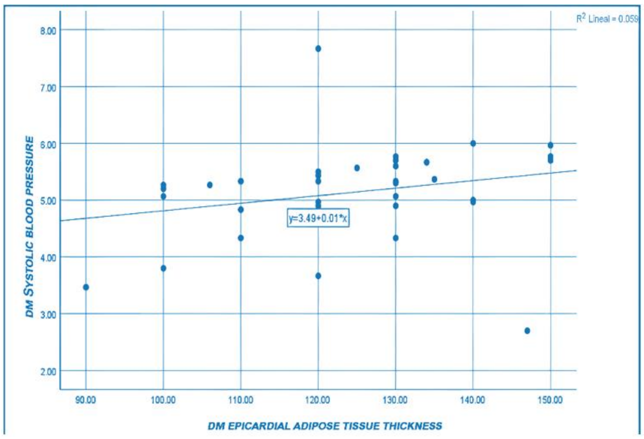

Fig 1: Positive correlation between epicardial adipose tissue thickness and increased systolic blood pressure in patients with DM. Pearson

The mean temperature in Group A is 21.1 ± 1.5°C, whereas in Group B, it is 18.7 ± 0.8°C (p=0.02) [see Fig 1]. The mean river precipitation in Group A is 368.54 ± 581 mm, while in Group B, it is 307.93 ± 445 mm, with no significant differences between the groups (p=0.08). The average number of dengue cases in Group A was 11,092 ± 9,425, and in Group B, it was 309 ± 342 (p=0.0001).

Table 1: Correlation between epicardial adipose tissue and atherogenic índices

	Castelli	Kannel	TG/HDL	SBP
All (p)	0.50 (0.68)	0.06 (0.62)	0.14 (0.22)	**0.33 (0.04)**
No DM (p)	-0.12 (0.45)	-0.13 (0.44)	-0.031 (0.85)	-0.006 (0.97)
DM (p)	0.14 (0.39)	0.28 (0.09)	0.26 (0.88)	**0.41 (0.013)**

TG/HDL: Triglycerides/ High-density cholesterol index, DM: Diabetes mellitus, SBP: Systolic blood pressure. Pearson.

The degree of correlation was determined using the Pearson parametric test between dengue as the dependent variable and river precipitation and temperature as independent variables, revealing a strong positive correlation between dengue and temperature (r=0.68, p=0.004).

When comparing the states within Group A, the mean temperature was 20.8 ± 2.5°C in Michoacán and 21.3 ± 1.0°C in Veracruz (p>0.05), the river precipitation was 54.26 ± 11.2 mm in Michoacán and 682 ± 1159 mm in Veracruz (p=0.03), and the number of dengue cases was 1755 ± 1087 in Michoacán and 9337 ± 9086 in Veracruz (p=0.03).

The Pearson correlation was repeated between the variables, with dengue as the dependent variable and river precipitation and temperature as independent variables. This time, a moderate positive correlation was found between dengue and river precipitation (r=0.55, p=0.02).

Table 2: Association between epicardial adipose tissue > 4.2 mm and atherogenic indices

	Castelli > 4.5	Kannel > 3	TG/HDL >3	SBP >140
n (%)				
All	13 (18.3 %)	14 (19.7%)	26 (36.6%)	6 (8.4 %)
No DM	2 (2.8%)	3 (4.2%)	2 (2.8%)	0 (0%)
DM	11 (15.4%)	11 (15.4%)	24 (33.8%)	6 (8.4%
OR (95% CI)				
All	1.50 (0.54 – 4.16)	1.11 (0.42 – 2.93)	1.46 (0.54 – 3.92)	**2 (0.45 – 8.72)***
No DM	1.16 (0.18 – 7.55)	1.72 (0.29 – 10.08)	0.28 (0.04 – 1.84)	N.A.
DM	N.A.	1.65 (0.15 – 17.82)	3.42 (0.40 – 28.94)	**0.72 (0.06 – 8.19)***

OR: Odds ratio, DM: Diabetes mellitus, SBP: Systolic blood pressure, CI: Confidence interval, TG/HDL: (*) Statistically significant.

4. Discussion

According to the obtained results, it is evident that the states in Group A possess the conducive conditions for the development of the mosquito vector of the disease. García *et al*. (2011) have stated that the mosquito reproduces and has greater abundance in conditions where the temperature exceeds 30.6°C, with precipitation ranging from 100 to 164 mm. Comparing the conditions in the states of Group A to the ideal conditions for vector reproduction, a compatibility for reproduction can be observed, resulting in an increased mosquito population. This, in turn, leads to a higher transmission of dengue. This aligns with what Hurtado *et al*. (2007) found in Veracruz from 1995 to 2003, where they reported that temperature and increased precipitation were the primary factors associated with rising dengue cases. Additionally, Brunkard *et al*. (2007) noted in their study that each degree increase in temperature and each additional millimeter of precipitation are associated with an increase in the incidence of dengue cases weeks after these phenomena occur.

In contrast, Group B does not possess suitable conditions for vector replication. This is evident in the lower mean temperatures and river precipitation levels, which fall below the optimal conditions outlined by various medical literature sources.

5. Conclusion

States with a tropical climate, defined internationally as having a temperature >18°C and precipitation >60 mm, exhibit a higher incidence of dengue cases compared to states with a dry climate. Among the ideal factors for the life cycle of the Aedes aegypti vector, they include precipitation >100 mm and a temperature >18°C.

In a general analysis of the studied federal entities, temperature is the factor that has the most significant impact on the presence of dengue cases due to its compatibility with the vector. However, when separately examining tropical states, those with higher river precipitation have a greater number of cases. This is because increased precipitation contributes to the ideal conditions for the reproduction and survival of the vector, leading to an increase in its population.

6. References

1. Arredondo-García JL, Aguilar-López Escalera CG, Aguilar Lugo-Gerez JJ, Osnaya-Romero N, Pérez-Guillé G, Medina-Cortina H. Panorama Epidemiológico de Dengue en méxico 2000-2019. Revista Latinoamericana de Infectología Pediátrica. 2020; 33(2):78-83. Doi: 10.35366/94418
2. Brunkard JM, Cifuentes E, Rothenberg SJ. Assessing the roles of temperature, precipitation, and ENSO in dengue re-emergence on the Texas-mexico border region. Salud Pública de México. 2008; 50(3). Doi: 10.1590/s0036-36342008000300006.
3. CENAPRECE. Consejo de salubridad general: Guía de práctica clínica: Manejo del dengue no grave y el dengue grave, 2008.
4. Gobierno de Mexico. Anuarios de morbolidad [Internet]. Available from: https://epidemiologia.salud.gob.mx/anuario/html/index.html.
5. García C, García L, Espinosa-Carreón TL, Ley PC. Abundancia y Distribución de Aedes aegypti (Diptera: Culicidae) y dispersión del dengue en Guasave Sinaloa, México. Revista de Biología Tropical. 2010; 59(4). Doi: 10.15517/rbt.v59i4.3424
6. Gómez H, Montesano R, López S, Tapia R. El dengue en México. Situación epidemiológica reciente. Gaceta Médica de México. 1995; 131(2):237-40.
7. González M. Datos de análisis serológicos y serotipos circulantes de Dengue Costa Rica, enero-diciembre, 2014. INCIENSA, 2015, 1-10. Available from: http://www.inciensa.sa.cr.
8. Hurtado-Díaz M, Riojas-Rodríguez H, Rothenberg SJ, Gomez-Dantés H, Cifuentes E. Short communication: Impact of climate variability on the incidence of dengue in Mexico. Tropical Medicine & amp; amp; International Health. 2007; 12(11):1327-1337. Doi: 10.1111/j.1365-3156.2007.01930.x.
9. Islam R, Salahuddin M, Ayubi MdS, Hossain T, Majumder A, Taylor-Robinson AW, *et al*. Dengue epidemiology and pathogenesis: Images of the future viewed through a mirror of the past. Virologica Sinica. 2015; 30(5):326-343. Doi: 10.1007/s12250-015-3624-1.
10. Maguiña C, Osores F, Suárez L, Soto L, Pardo K. Dengue clásico y hemorrágico: Una Enfermedad reemergente y emergente en el Perú. Revista Medica Herediana. 2013; 16(2):120. Doi: 10.20453/rmh.v16i2.826.
11. Martina BE, Koraka P, Osterhaus AD. Dengue virus pathogenesis: An integrated view. Clinical Microbiology Reviews. 2009; 22(4):564-581. Doi: 10.1128/cmr.00035-09.
12. Bhatt S, Gething PW, Brady OJ, Messina JP, Farlow AW, Moyes CL, *et al*. The Global Distribution and burden of Dengue. Nature. 2013; 496(7446):504-507. Doi: 10.1038/nature12060.
13. Sistema meteorológico nacional. Resúmenes mensuales de temperaturas y lluvia [Internet]. Available from: https://smn.conagua.gob.mx/es/climatologia/temperaturas-y-lluvias/resumenes-mensuales-de-temperaturas-y-lluvias
14. Velandia ML, Castellanos JE. Virus del dengue: Estructura y ciclo viral. Infectio. 2011; 15(1):33-43. Doi: 10.1016/s0123-9392(11)70074-1.
15. Torres-Galicia I, Cortés-Poza D, Becker I. Dengue en México: Análisis de dos décadas. Gaceta Medica De México. 2014; 150:122-127.